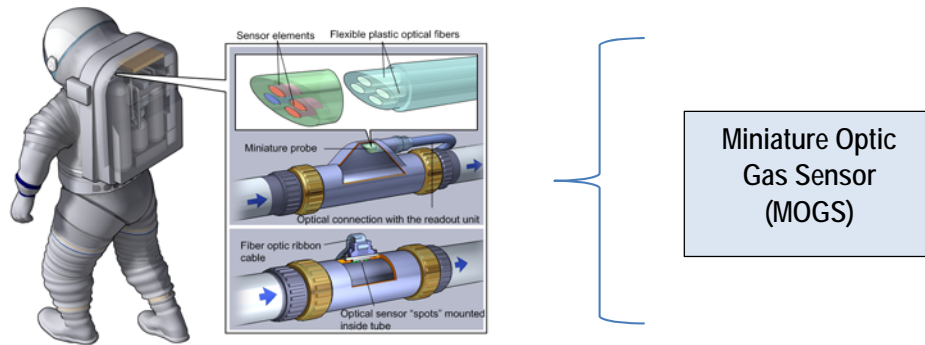


## Advancement of Miniature Optic Gas Sensor (MOGS) Probe Technology



### Abstract

"Advancement of Miniature Optic Gas Sensor (MOGS) Probe Technology" project will investigate newly developed optic gas sensors delivered from a Small Business Innovative Research (SBIR) Phase II effort. A ventilation test rig will be designed and fabricated to test the sensors while integrated with a Suited Manikin Test Apparatus (SMTA). Once the sensors are integrated, a series of test points will be completed to verify that the sensors can withstand Advanced Suit Portable Life Support System (PLSS) environments and associated human metabolic profiles for changes in pressure and levels of Oxygen ( $\text{ppO}_2$ ), carbon dioxide ( $\text{ppCO}_2$ ), and humidity ( $\text{ppH}_2\text{O}$ ).

### Detailed Description

Space suit life support systems are critically necessary for the successful support of the International Space Station (ISS) and future human space exploration missions for in-space micro-gravity Extravehicular Activity (EVA) and planetary surface operations. NASA has experienced a history of failures with the existing carbon dioxide ( $\text{CO}_2$ ) gas sensor for the current Extravehicular Mobility Unit (EMU). The failure of the current sensor technology is due to the high humidity environment of the space suit. In addition, NASA is presently developing an Advanced EMU (AEMU) Portable Life Support System (PLSS) for exploration missions. The PLSS attaches to the spacesuit pressure garment and provides approximately an 8 hour supply of oxygen for breathing, suit pressurization, ventilation; humidity, trace- contaminant, carbon dioxide ( $\text{CO}_2$ ) removal; and a thermal control system for crew member metabolic heat rejection. These missions will also require robust, lightweight, low-power, durable sensors for monitoring critical life support constituents in the suit.

This project will take a newly developed innovative miniature optic gas sensor (MOGS) technology and integrate it into a specially designed ventilation test loop of the PLSS. This ventilation test loop will then be integrated with the existing Suited Manikin Test Apparatus (SMTA) in order to test real environmental parameters associated with the PLSS in a simulated spacesuit environment. The SMTA is a NASA agency unique breathing manikin that simulates metabolic responses of an astronaut breathing in a spacesuit. The new optic gas sensor will be delivered by Intelligent Optical Systems (IOS) as part of an Small Business Innovative Research (SBIR) Phase II and one optic sensor will be provided in-kind (at no cost) by IOS as a collaborative effort for this project. A ventilation test rig will be designed and fabricated to test the sensors while integrated with the SMTA. Once the sensors are integrated, a series of test points will be completed to verify that the sensor can withstand PLSS environments and associated human metabolic profiles for changes in pressure and levels of Oxygen ( $\text{ppO}_2$ ), carbon dioxide ( $\text{ppCO}_2$ ), and humidity ( $\text{ppH}_2\text{O}$ ) in the proposed test loop.

Partnerships: This project engages a multifaceted collaboration team. The collaborators includes multiple NASA centers (JSC & GRC), other federal agencies (Navy), multiple NASA programs, multiple vendors including small businesses, and multiple engineering and scientific disciplines. The JSC PLSS lab will be location of the integration and testing. A small business will provide the MOGS technology.

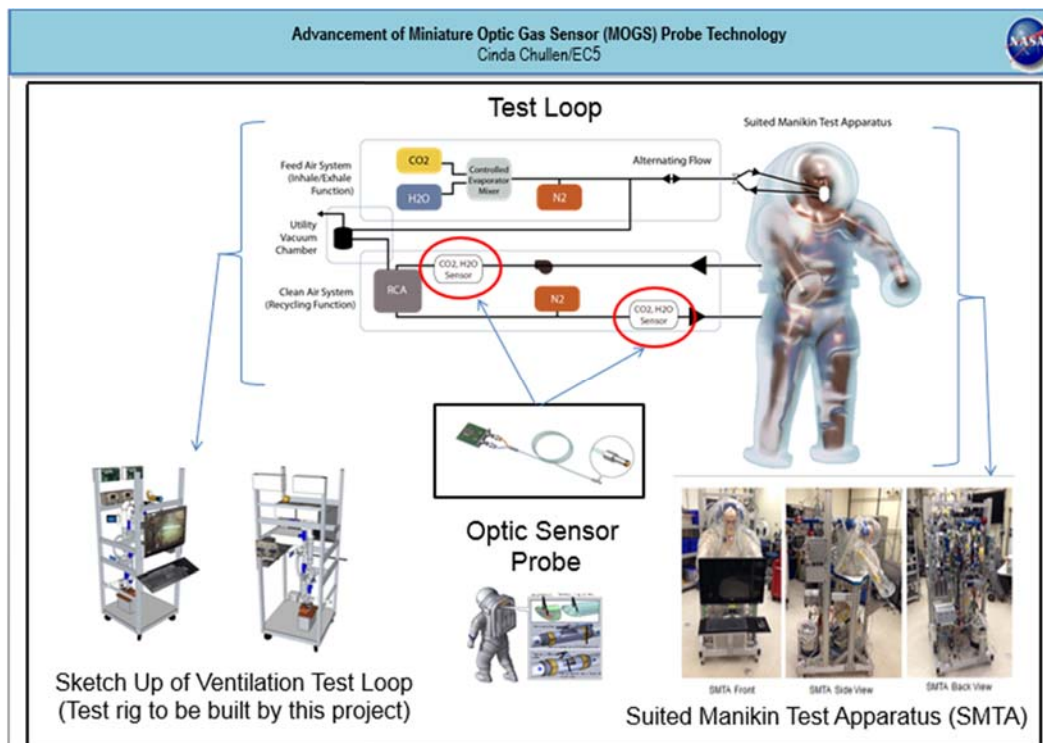
## Benefits to NASA and non-NASA

Non-dispersive infrared (NDIR) sensing technology remains the current state of the art technology for measuring CO<sub>2</sub> and has difficulty operating in the presence of water in the current spacesuit. The current spacesuit CO<sub>2</sub> gas sensor has a history of failing during spacewalks due to excess moisture in the suit. The miniature optic gas sensors (MOGS) technology has the potential to tolerate liquid water and operate while wet, and can could remotely connect to electronic circuitry by an optical fiber cable immune to electromagnetic interference. The newly developed MOGS have the potential for infusion into the current International Space Station space suit and into the test bed for the advanced space suit. The MOGS technology could be infused into the aeronautics industry. In particular, the new technology sensor probes could be integrated into flight crew air supply. Also, the technology could be used for biomedical monitoring for measuring pCO<sub>2</sub> and PO<sub>2</sub>.

## Technology Description

This project will evaluate and validate the performance of the MOGS technology within the advanced suit PLSS environment. The MOGS sensing technology is a luminescence-base fiber optic sensor technology consisting of an indicator chemistry immobilized in a polymer film. The feasibility of the technology has already been demonstrated under Small Business Innovative Research (SBIR) Phase I and Phase II contracts with NASA. The MOGS technology will be delivered at a technology readiness level (TRL) level of 4 from the Phase II contract. A PLSS ventilation loop schematic will be created to integrate the new sensors with the focus of advancing the TRL. Proper interfaces, functionality, and installation of the sensors with the ventilation test rig will be accomplished. Test points will be prepared and documented into a test plan to validate the full range of performance of the sensors. A test rig will be fabricated at JSC building 7A, room 2006. The test rig will be a simulated ventilated loop of the advanced PLSS. This test loop will contain a CO<sub>2</sub> removal system (currently targeted for Rapid Cycle Amine 3.0), a commercial-off-the-shelf (COTS) fan, and separate COTS CO<sub>2</sub> sensors. The COTS sensors will be added to provide validation of the MOGS readings. The MOGS Sensor #1 and Sensor #2 will be integrated into the ventilation test rig. The entire system will be integrated and operated with LabVIEW. Once the system has been assembled appropriately, a test readiness review (TRR) will be held to make sure all operations of the applicable test rig are performed in a safe manner.

The goal and expected outcome will be to advance this MOGS technology from a TRL 4 to a TRL 5. Testing these optic sensor probes will help the advancement of the Advanced PLSS, the functionality of the Advanced PLSS, and could assist with monitoring open and closed loop-looped environmental control and life support systems (ECLSS).



### **Technology Area(s)**

The MOGS technology has the potential to infuse into the Portable Life Support System (PLSS) of the Advanced Space Suit and the current International Space Station Space Suit. The capability could provide CO<sub>2</sub>, humidity, and O<sub>2</sub> monitoring in a miniature form in the PLSS ventilation loop in unison. For the Advanced PLSS, the MOGS probes could augment the Rapid Cycle Amine CO<sub>2</sub> removal technology and overcome issues of detection in the presence of H<sub>2</sub>O. The MOGS is applicable to and has strategic alignment to the HAT: 6.1.a, 6.1.b, 6.2.c, 6.4.a, 7.3.b, TABS: 6.1.1 to 6.1.4, 6.4.1, 7.3.1, and SMT: 311.

- 6.1.a Closed Loop, High Reliability, Life Support: Testing this optic sensor probe will progress it from TRL 4 to TRL 5 and could assist with monitoring open and closed loop-looped environmental control and life support systems (ECLSS). Being smaller than any sensor developed thus far, integrating it into existing test rigs will facilitate multiple vehicle and mission applications.
- 6.1.b High Reliability, Life Support Systems: Testing this sensor can verify tolerance to more extreme conditions (operation in the presence of water), reduces pressure, and elevated O<sub>2</sub> levels, therefore offering a more robust and reliable component.
- 6.2.c Mars Surface Space Suit: Evaluation of this technology will be in a subsystem of the AEMU PLSS built under this project and integrated with the SMTA previously built. Testing will help characterize this probe for AEMU PLSS environments.
- 6.4.a In-Flight Environmental Monitoring: This sensor can provide the air monitoring that is much smaller than the current state of the art technology.
- 7.3.b Suit Port: By monitoring atmospheric gases such as CO<sub>2</sub>, O<sub>2</sub>, and H<sub>2</sub>O, it can facilitate reducing exposure or providing adequate exposure to these gases.
- 311 EVA SMT CO<sub>2</sub> Sensor: The Optic gas sensor TRL will be increased by testing under EVA simulated conditions and verifying susceptibility to H<sub>2</sub>O.

### **Technology Readiness Level**

The MOGS probes will be delivered at a TRL level of 4. The overall goal of the SBIR Phase II development of the MOGS probes was to fabricate and test a working model of an optical flow-through monitor for partial pressure of O<sub>2</sub>, CO<sub>2</sub>, and H<sub>2</sub>O, suitable for NASA Advanced PLSS applications. The goal was to develop an initial prototype of a compact, low-power phase-resolved luminescence detector. Once the MOGS probes are received they will be tested in a ground-based test rig to prove out their performance in applicable environments.